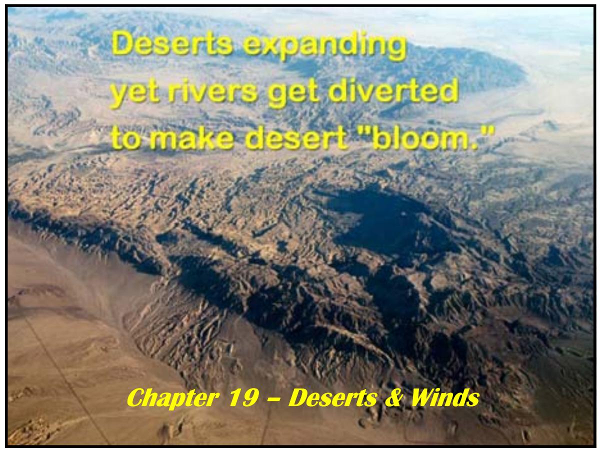
Deserts and Winds

Earth – Chapter 19



Distribution and Causes of Dry Lands

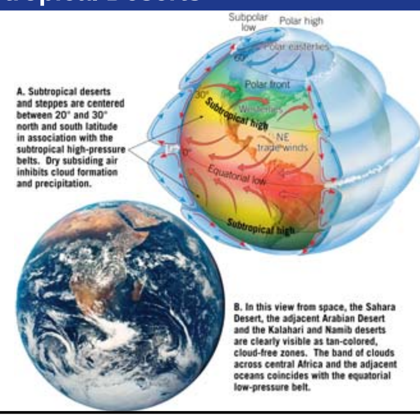
- What Is Meant by *Dry*?
  - A **dry climate** is one where yearly precipitation is not as great as the potential for evaporation
  - Dry regions cover 30 percent of Earth's land surface
  - Two water-deficient climatic types are commonly recognized
    - **Desert** (or arid) regions, and
    - **Steppe** (or semiarid) regions
- **Desertification**: the persistent degradation of dry-land ecosystems—desert-like conditions are expanding worldwide

Dry Climates

Distribution and Causes of Dry Lands

- Subtropical Deserts and Steppes
  - Lie between the Tropics of Cancer and Capricorn
    - Virtually unbroken desert environment stretching for more than 9300 kilometers
  - Subsiding air masses
    - The basic cause of bands of arid and semi-arid areas
    - Regions of high pressure (sinking air that is compressed and warmed)
      - Few chances for cloud formation and precipitation

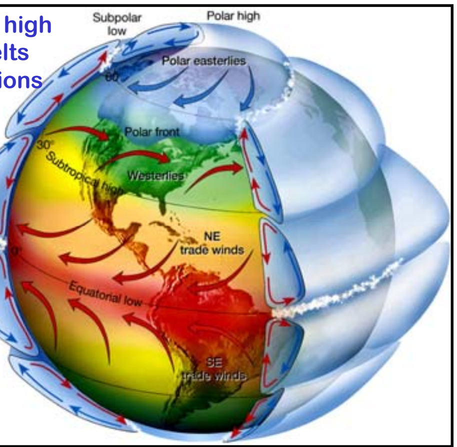
Subtropical Deserts

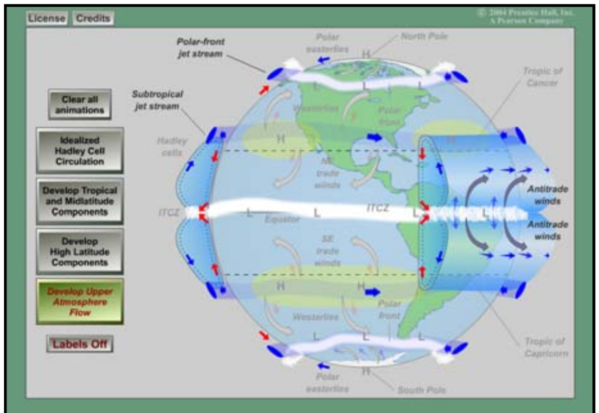


A. Subtropical deserts and steppes are centered between 20° and 30° north and south latitude in association with the subtropical high-pressure belts. Dry subsiding air inhibits cloud formation and precipitation.

B. In this view from space, the Sahara Desert, the adjacent Arabian Desert and the Kalahari and Namib deserts are clearly visible as tan-colored, cloud-free zones. The band of clouds across central Africa and the adjacent oceans coincides with the equatorial low-pressure belt.

Subtropical high pressure belts and dry regions





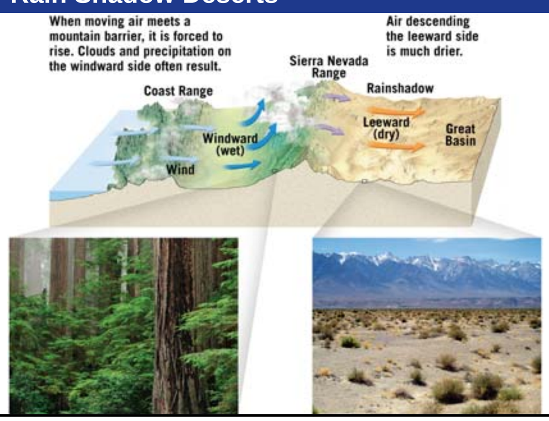
Distribution and Causes of Dry Lands

- Subtropical Deserts and Steppes
  - **West Coast Subtropical Deserts**
    - Cold ocean current cools air and prevents it from rising
      - Few chances for cloud formation and precipitation
      - Often foggy areas
        - » Atacama Desert, South America
        - » Namib Desert, south-western Africa

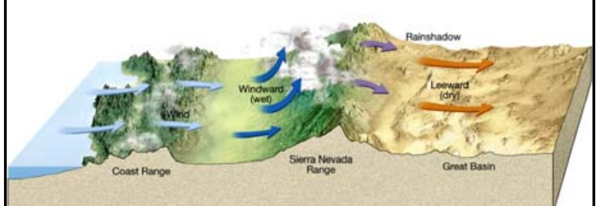
Distribution and Causes of Dry Lands

- Middle-Latitude Deserts and Steppes
  - Sheltered in deep interiors of large landmasses
    - Far-removed from ocean moisture
      - Gobi Desert, central Asia
  - Mountain barriers
    - As prevailing winds meet mountains, the air is forced to ascend where it rises, expands and cools, producing clouds and precipitation
    - Air flowing over the leeward side of the mountain is dry and forms a **rainshadow**
      - Coast Ranges, Sierra Nevada and Cascades, North America

Rain Shadow Deserts



Rainshadow desert



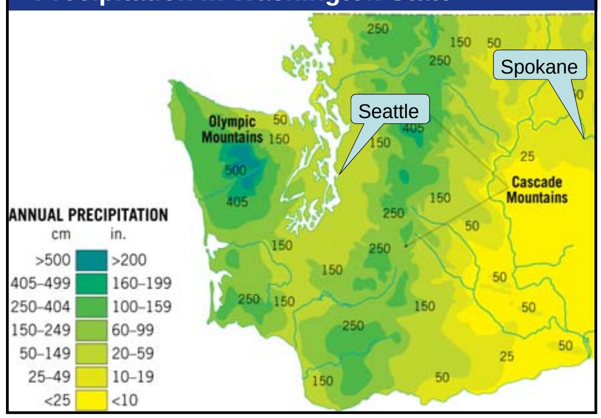
Average Annual Precipitation Defining the Boundary Between Dry and Humid Climates

Average Rainfall Annual Temp. (C°)	Winter Rainfall Maximum (centimeters)	Even Distribution (centimeters)	Summer Maximum (centimeters)
5	10	24	38
10	20	34	48
15	30	44	58
20	40	54	68
25	50	64	78
30	60	74	88

Monterrey (west of Sierra Nevada):
Average annual precipitation - rainfall: 8.50 cm
Average temperature: 13.25˚ C

Bishop (east of Sierra Nevada):
Average annual precipitation - rainfall: 2.05 cm
Average temperature: 13.53˚ C

Precipitation in Washington State



Average Annual Precipitation Defining the Boundary Between Dry and Humid Climates

Average Rainfall Annual Temp. (C°)	Winter Rainfall Maximum (centimeters)	Even Distribution (centimeters)	Summer Maximum (centimeters)
5	10	24	38
10	20	34	48
15	30	44	58
20	40	54	68
25	50	64	78
30	60	74	88

Seattle (west of Cascades):
Average annual precipitation - rainfall: 13.4 cm
Average temperature: 11.08˚ C

Spokane (east of Cascades):
Average annual precipitation - rainfall: 6.5 cm
Average temperature: 8.92˚ C

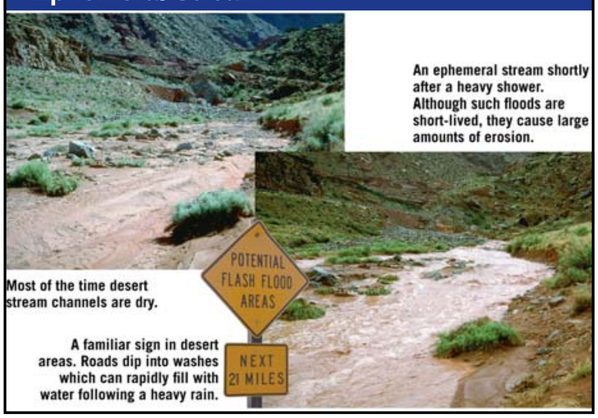
Geologic Processes in Arid Climates

- Weathering
  - Chemical weathering processes not as prominent
  - Mechanical weathering more prominent
  - Some chemical weathering does occur over long spans of time
    - Produces clay, thin soils, and oxidation of iron-rich sediments

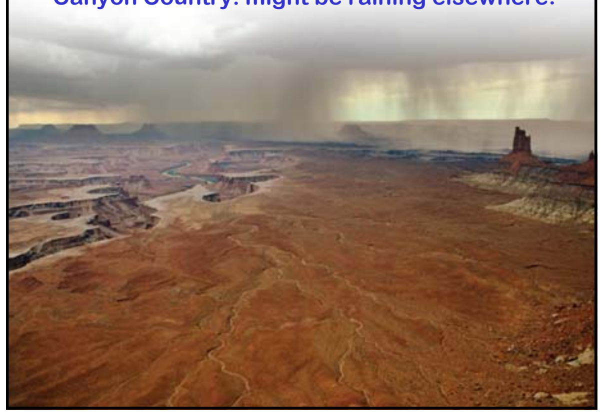
Geologic Processes in Arid Climates

- The Role of Water
  - Water still plays an important role in shaping dry landscapes
  - Most streambeds are dry most of the time
    - **Ephemeral streams** (intermittent streams) only carry water in response to specific periods of rainfall
      - May only flow a few days or hours a year
    - When rain falls, it is too much to soak in and most of it flows as runoff into the streambeds
      - Desert floods arrive suddenly and subside quickly

Ephemeral Stream



Canyon Country: might be raining elsewhere!



Antelope Canyon

And you won't know until you hear a roaring sound…

The Importance of Running Water

Geologic Processes in Arid Climates

- Different names are used for ephemeral streams in various regions
  - *Wash* and *arroyo* (western United States)
  - *Wadi* (Arabia and North Africa)
  - *Donga* (South America)
  - *Nullah* (India)

Wadi in North Africa

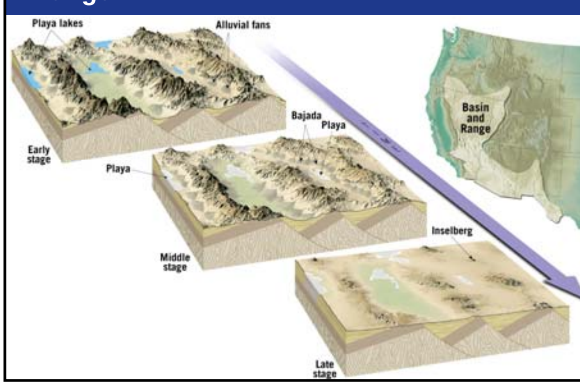
Geologic Processes in Arid Climates

- The Role of Water
  - Some permanent streams do cross arid regions
    - Originate *outside* the desert in well-watered mountains
    - Must contain enough water to compensate for loss from evaporation in arid region
      - Example: Colorado and Nile Rivers
  - While infrequent, running water does *most* of the erosional work in deserts

Basin and Range: The Evolution of a Desert Landscape

- Arid regions typically have **interior drainage** because the intermittent streams do not flow to the ocean
  - *Basin and Range* province has basins, local base levels, so erosion occurs without reference to the ocean
- Landscape evolution
  - Uplift of mountains
  - Running water erodes and transports materials to the basin

Landscape Evolution in the Basin and Range



Basin and Range: The Evolution of a Desert Landscape

- Landscape Evolution
  - Sediment-laden rivers from sporadic rains deposit debris at the mouth of a canyon
    - Runoff spreads out over gentler slopes and quickly loses velocity
    - This fan-shaped sediment deposit is called an **alluvial fan**
      - Coarsest material deposited first
    - A **bajada** forms from the coalescing of multiple fans

Basin and Range: The Evolution of a Desert Landscape

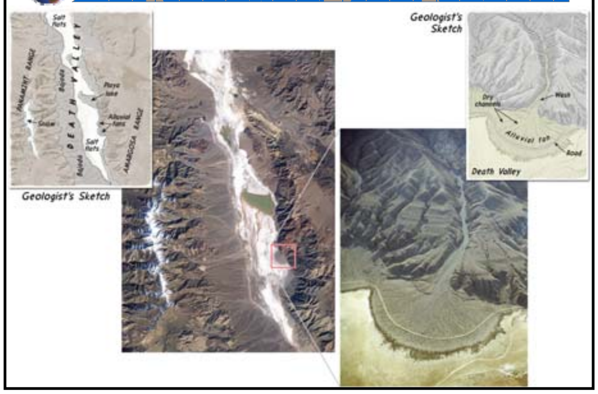
- Landscape Evolution
  - During heavy rainfall, streams flow across the bajada to form a shallow, short-lived **playa lake**
    - The dry, flat lake bed left after the water evaporates is called a **playa**
  - Continued erosion diminishes the mountains to a few isolated bedrock knobs called **inselbergs**

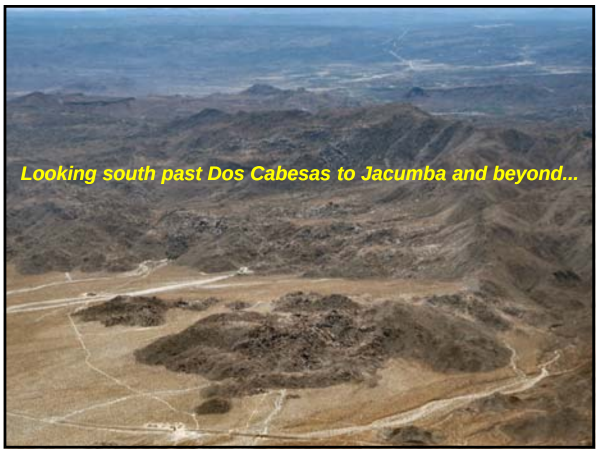
Basin and Range

Playa in Death Valley

Death Valley

Death Valley





Inselbergs in southern California

Transportation of Sediment by Wind

- Differs from that of running water in two ways:
  - Wind is lower density and less capable of picking up and transporting coarse materials
  - Wind is not confined to channels and can spread sediment over large areas

Transportation of Sediment by Wind

- Bed Load
  - The **bed load** is carried by wind close to the surface
    - Consists mostly of sand grains
    - Sand moves across the surface in a process called **saltation** (by bumping and skipping)
  - Height of the bed load rarely exceeds one meter above the surface, generally no higher than 0.5 meters

Transporting Sand

Transportation of Sediment by Wind

- Suspended Load
  - The **suspended load** is carried high into the atmosphere
    - Consists mostly of silt-sized particles
      - Surface area must be high compared to weight
      - Example: flat clay particles
    - Hard to move fine particles unless they have been disturbed on the surface
      - Example: a clay road with and without a car driving over it
    - The suspended load can be transported far distances
      - Dust from the Sahara can reach the Caribbean

Wind's Suspended Load

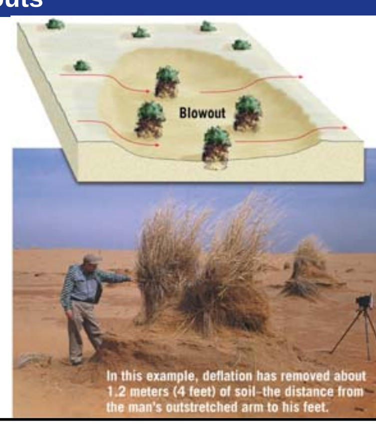
Wind Erosion

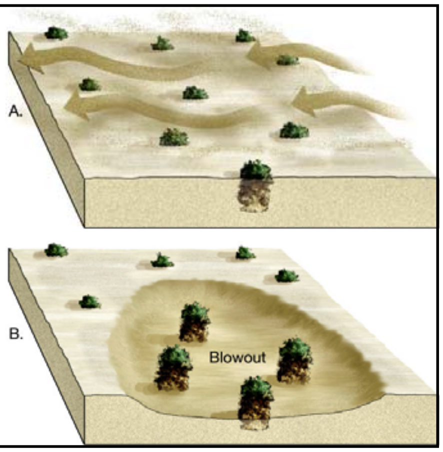
- Compared with glaciers and running water, wind is an insignificant erosional agent
  - More effective in arid regions
    - Dryness and scant vegetation are important for wind to be effective at eroding
      - Example: Dust Bowl in 1930s

Wind Erosion

- Deflation and Blowouts
  - **Deflation** is the lifting and removal of loose material
    - Hard to notice because the entire surface is being lowered
      - During the Dust Bowl, vast areas were lowered by one meter in a few years
  - Deflation also produces **blowouts** (shallow depressions)
    - Can range from small dimples to depressions that are
      50 meters deep and several kilometers across

Blowouts





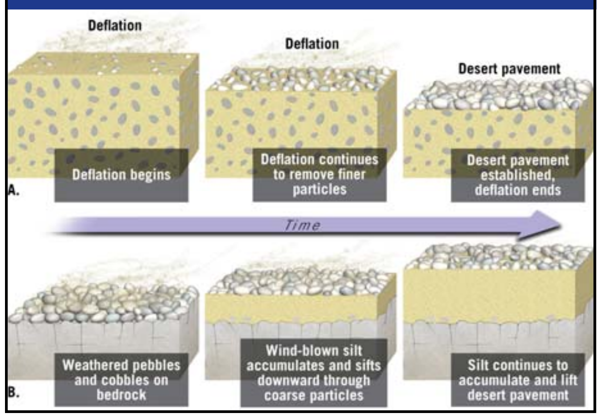
Formation of a desert blowout

Wind Erosion

- Desert Pavement
  - Many deserts have a veneer of pebbles and cobble called **desert pavement**
  - Forms from an initial surface of coarse pebbles
    - Fine, windblown grains are trapped between the pebbles
    - Gravity and infiltrating rainwater move the fine sediments beneath the cobbles

Desert Pavement

Formation of Desert Pavement



Wind Erosion

- Ventifacts and Yardangs
  - Wind also erodes by **abrasion** (scraping)
    - Windblown sand *cuts and polishes* rock surfaces
    - Creates interestingly shaped stones called **ventifacts**
  - Wind also creates streamlined landforms oriented parallel to the prevailing wind direction called **yardangs**

Shaped by the Wind

A. B.

Ventifact

Yardang

Wind Deposits

- Two types of depositional landforms are created by wind
  - **Dunes**
    - mounds and ridges of sand from the wind's bed load
  - **Loess**
    - extensive blankets of silt once carried in suspension

Wind Deposits

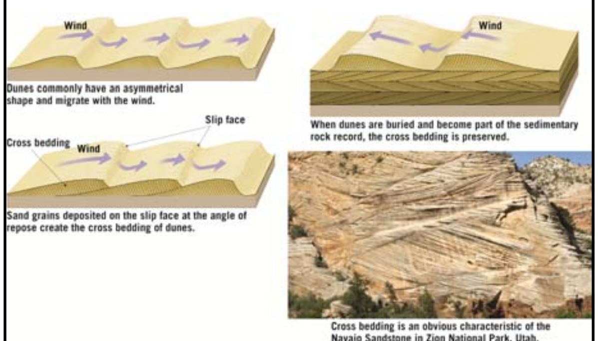
- Sand Deposits
  - Sand will accumulate wherever an obstruction blocks wind flow, creating a **dune**
    - Dunes often form around a clump of vegetation or rocks
    - Most dunes have an *asymmetrical profile*
      - Windward slope is gently inclined and the steeper leeward slope is called the **slip face**
        - » The slip face typically maintains an angle of 34 degree (the angle of repose for sand)

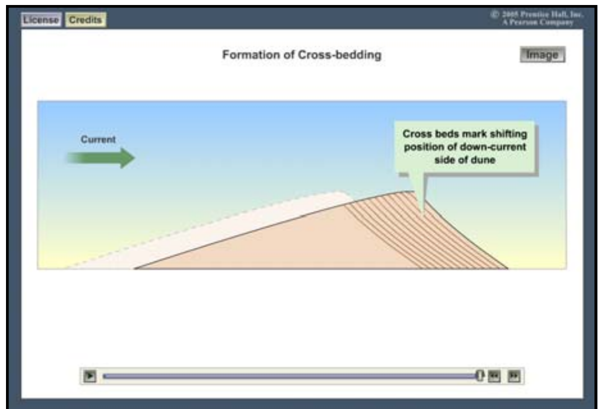
White Sands National Monument

Wind Deposits

- Sand Deposits
  - As sand is deposited on the slip face, layers form *inclined to prevailing wind direction*, creating **cross bedding**
  - Moving sand can be troublesome for permanent structures like roads and buildings

Cross Bedding

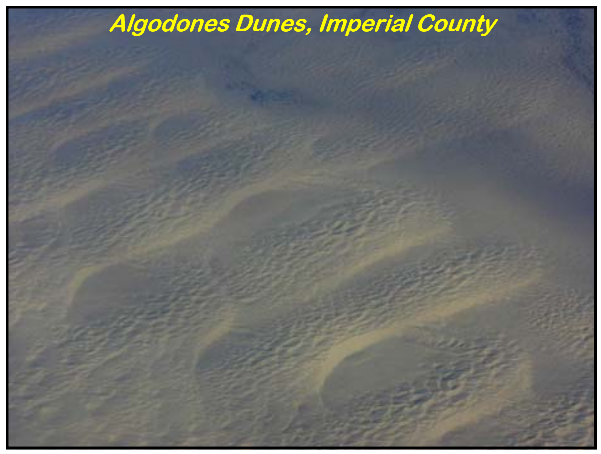




Moving Sands

Kelso Dunes, Mojave National Preserve

Spider on Sand Dune Slipface, Hensler, ND



Algodones Dunes, Imperial County

"Fossil" Dunes, Navajo Sandstone, Utah

"Fossil" Dunes, near Kanab, Utah

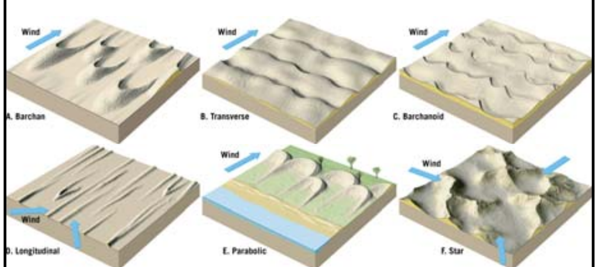
Wind Deposits

- Types of Sand Dunes
  - Dunes are classified into six basic types *based on their size and shape*
  - **Barchan dunes** are solitary sand dunes shaped like crescents
    - Form where sand supplies are limited and the surface is flat, hard, and lacking vegetation
  - **Transverse dunes** are a series of long ridges oriented at right angles to prevailing winds
    - Form where sand is plentiful and vegetation is sparse
      - Most coastal beach dunes are transverse dunes
  - **Barchanoid dunes** are a intermediate form of dune between barchan and transverse dunes

Wind Deposits

- Types of Sand Dunes
  - **Longitudinal dunes** form parallel to prevailing winds where sand supplies are moderate
  - **Parabolic dunes** form when vegetation partially covers the sand
  - **Star dunes** are isolated hills of sand that develop when wind directions are variable

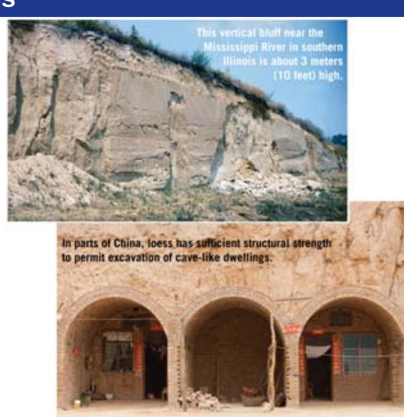
Types of Sand Dunes

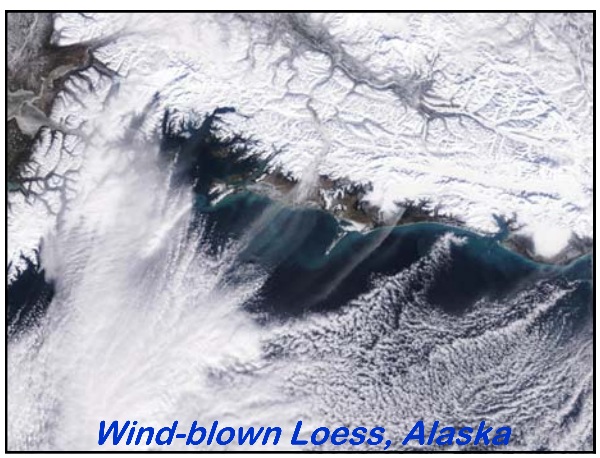


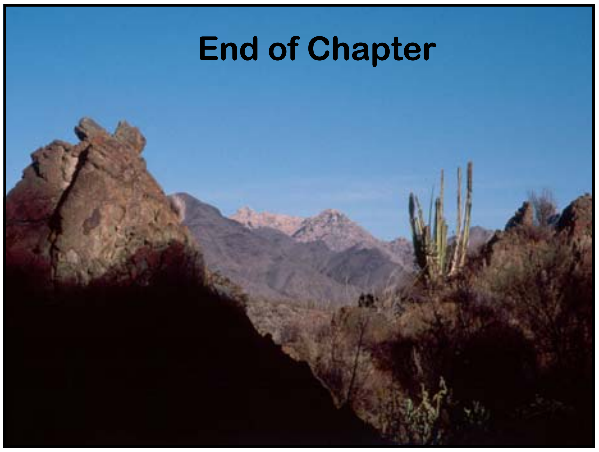
Wind Deposits

- **Loess (Silt) Deposits**
  - Windblown silt deposits
  - Material is deposited by storms over thousands of years
    - Sources of sediments come from deserts and glacial outwash deposits
      - Loess in China originates from desert basins in central Asia
      - Loess in the United States and Europe is the product of glacial material

Loess






End of Chapter